

TWO TYPES OF BLUE WHALE CALLS RECORDED IN THE GULF OF ALASKA

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ABSTRACT

At one time blue whales were found throughout the Gulf of Alaska, however, none have been sighted there in post-whaling era surveys. To determine if blue whales (*Balaenoptera musculus*) might now occur in the Gulf of Alaska, an array of hydrophones was deployed there in October 1999. Data were retrieved in May 2000 and in June 2001. Spectrograms from a random subsample comprising 15% of the ~63,000 h of data were visually examined for blue whale calls. Call types attributed to both northeastern and northwestern Pacific blue whales were recorded. Both of these call types were recorded seasonally from the initial deployment date in October 1999 through the third week of December 1999 and then from July 2000 through mid-December 2000. Both call types were regularly recorded on the same hydrophone at the same time indicating clear temporal and spatial overlap of the animals producing these calls. Two blue whale call types were recorded in the Gulf of Alaska suggesting that perhaps two stocks use this area. The northeastern call type has now been documented from the equator up to at least 55°N in the eastern North Pacific.

Key words: blue whale, *Balaenoptera musculus*, Gulf of Alaska, acoustics, geographic variation.

Blue whales (*Balaenoptera musculus*) are found throughout the North Pacific Ocean (Mizroch *et al.* 1984) but the population is not well known. The International Whaling Commission (IWC) currently recognizes only one stock of blue whales in the North Pacific (Donovan 1991). However, there may be more than one and possibly as many as five populations (Ohsumi and Wada 1973, NMFS 1998, Forney *et al.* 2000). These five include an eastern North Pacific population (formerly California/Mexico stock), northwestern (Northern Japan/Kamchatka area) and central (Aleutian Islands) Pacific population, a southern Japan/Korea population that may have been completely extirpated, and an eastern Gulf of Alaska population (NMFS 1998). Additionally, the National Marine Fisheries Service

currently recognizes a stock of blue whales in Hawaiian waters, although sightings are extremely rare.¹

The eastern North Pacific population is the only one for which there is information on population structure. This population is thought to undergo annual north-south migrations (Mizroch *et al.* 1984). Blue whales winter as far south as the eastern tropical Pacific (Mate *et al.* 1999, Stafford *et al.* 1999a) and are found in considerable numbers during summer and fall months feeding in California waters (Calambokidis *et al.* 1990). Acoustic data place animals from this population as far north as Oregon and Washington in the fall and early winter (McDonald *et al.* 1995, Stafford *et al.* 1999a). Clarifying the population structure of North Pacific blue whales and identifying the seasonal movements of these populations are essential components to reasonable management of this endangered species.

Currently, there are four subspecies of blue whales recognized worldwide: *B. m. intermedia* from the Antarctic, *B. m. musculus* from the Northern Hemisphere, *B. m. brevicauda* from the Subantarctic Zone, and *B. m. indica* from the northern Indian Ocean (Rice 1998). However, there are more than four blue whale acoustic signatures worldwide. Although all blue whale calls share the characteristics of being low frequency and long duration, animals recorded in different regions of the world produce distinctly different sounds. These geographic differences may be useful in discriminating different populations of blue whales based on their call type (Thompson *et al.* 1996). To date, different blue whale sounds have been documented for the Atlantic (Edds 1982), the North Pacific (Thompson and Friedl 1982, Rivers 1997, Stafford *et al.* 2001), the west coast of South America (Cummings and Thompson 1971, Stafford *et al.* 1999b), the Antarctic,² Madagascar (Ljungblad *et al.* 1998) and the Indian Ocean (Alling *et al.* 1991). There are not yet any data from the South Atlantic.

Two call types attributed to blue whales in the North Pacific have been reported: the northeastern Pacific blue whale call type is well known and recorded from locations in the northeast Pacific ranging from the equator along the west coast of North America up to southern Vancouver Island (McDonald *et al.* 1995, Thompson *et al.* 1996, Clark and Fristrup 1997, Rivers 1997, Stafford *et al.* 1999a, Stafford *et al.* 2001). The northwestern Pacific blue whale call type is less well known, but has been recorded from hydrophones near Kaneohe, Hawaii, Midway Island, and locations along the Aleutian Islands and the northwest Pacific (Northrup *et al.* 1971, Thompson and Friedl 1982, Stafford *et al.* 2001). There have been no acoustic data recorded in the Gulf of Alaska.

Blue whales were regularly hunted in the Gulf of Alaska by Japanese, Russian, American, and Canadian whalers (Pike 1954, Berzin and Rovnin 1966, Nishiwaki 1966, Mizroch *et al.* 1984, Brueggeman *et al.* 1985, Gregr *et al.* 2000). The whaling season in the Gulf of Alaska/Aleutian chain region was May-October (Brueggeman *et al.* 1985) with most whales taken from June to August (Stewart *et al.* 1987). Nevertheless, shipboard and aerial surveys of areas formerly hunted by whalers during these months found no blue whales¹ (Rice and Wolman 1982, Stewart *et al.* 1987).

¹ Forney, K. A., and R. L. Brownell, Jr. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. Unpublished document submitted to the Scientific Committee of the International Whaling Commission, Cambridge, UK. SC/48/O. 15 pp.

² Clark, C. W., and M. Fowler. 2001. Status of archival and analysis efforts of acoustic recordings during SOWER and IWC cruises 1996-2000. Paper SC/53/IA28 submitted to the Scientific Committee of the International Whaling Commission.

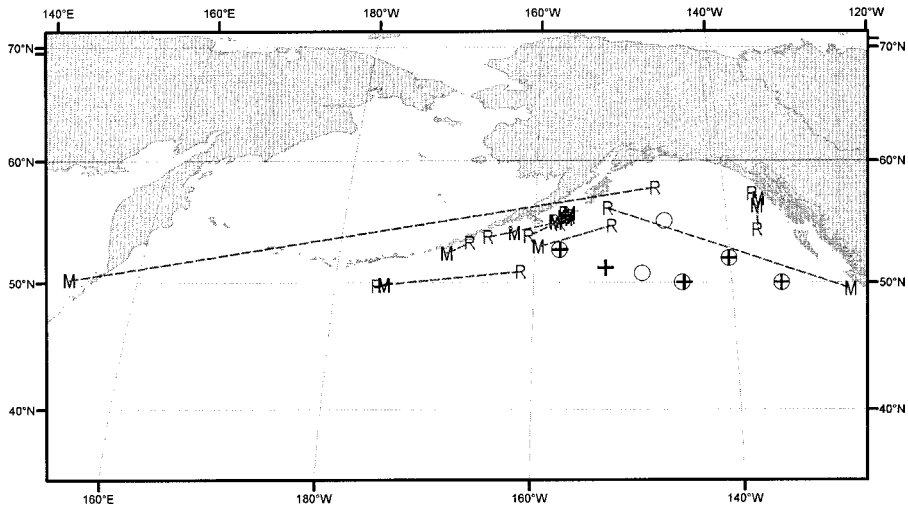


Figure 1. Locations of hydrophones moored in the Gulf of Alaska from October 1999 to May 2001. Hydrophones moored in 1999 are shown as open circles (O) and those moored in 2000 are shown as plus symbols (+). Discovery tag mark-recapture locations are also shown in this figure. Mark (M) and recovery (R) data locations were obtained from Omura and Ohsumi (1964), Ivashin and Rovnin (1967), and Ohsumi and Masaki (1975). Lines connecting marks and recoveries are shown to associate the locations at which whales were marked and then harvested and do not represent actual animal movements.

Calls recorded near the central Aleutians suggest that whales taken there by commercial whalers probably belonged to the northwestern Pacific population (Stafford *et al.* 2001). Assigning whales taken in the Gulf of Alaska to an eastern versus western population is more problematic. There are published reports of seventeen Discovery tag mark-recoveries from blue whales in the north Pacific (Omura and Ohsumi 1964, Ivashin and Rovnin 1967, Ohsumi and Masaki 1975). Eleven whales were marked and recovered along the Aleutian Islands (Fig. 1). Two were marked and recovered in the eastern Gulf of Alaska and two were marked and recovered off Hokkaido. Of particular interest are two mark-recoveries that show blue whales moving great distances. One animal was marked near Vancouver Island in May and killed just over a year later 1,772 km (great circle distance) to the northwest by the southern coast of Kodiak Island in June. A second mark (erroneously recorded as shot into a sperm whale but recovered from a blue whale) was implanted southeast of the Sea of Okhotsk in May and recovered 3,852 km away four years later in June in the north-central Gulf of Alaska. Blue whales recorded off Vancouver Island, Canada, are known to make the northeastern Pacific call type (Stafford *et al.* 1998, 1999a), whereas those near the Sea of Okhotsk make the northwestern Pacific call type (Stafford *et al.* 2001). These tag recoveries indicate that animals from both regions have used the Gulf of Alaska and thus both North Pacific call types might be recorded there.

METHODS

The National Oceanic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory (PMEL) deployed hydrophones (Fox *et al.* 2001)

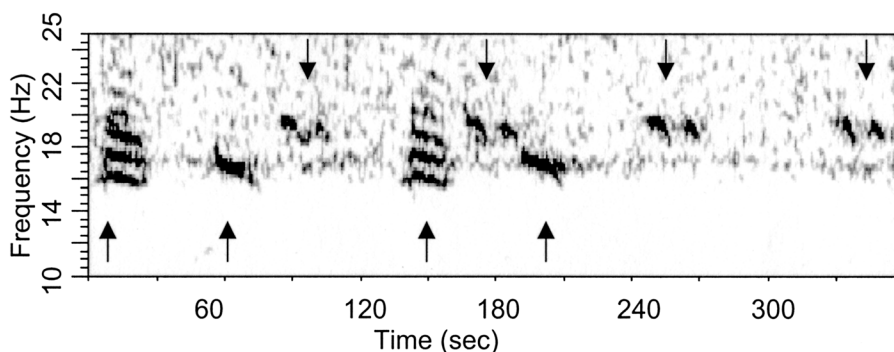


Figure 2. Spectrogram of northeastern (↑) and northwestern (↓) blue whale calls recorded on a hydrophone in the Gulf of Alaska (FFT 4.0 sec, 87.5% overlap, 0.2 Hz frequency resolution). The simultaneous presence of both call types on a single hydrophone clearly shows that the two stocks coexist in the Gulf of Alaska region.

in the Gulf of Alaska to record whale calls. In October 1999, six hydrophones were moored in the Gulf of Alaska (Fig. 1) from the NOAA ship *Ronald H. Brown*. The instruments were moored such that the hydrophone would be within the deep sound channel (300–500 m below sea level based on sound speed profiles). Data were archived on board the instruments as digital files. The instruments recorded data from 0.1 to 440 Hz (sample rate 1,000 samples/sec). The six instruments were first retrieved in May 2000, the data downloaded and the instruments redeployed and subsequently recovered in June 2001. The northernmost hydrophone at 55°N, 146.5°W was not redeployed because this location was considered too far away from the other instruments to be serviced regularly. Also, the hydrophone at 50.7°N, 149°W was moved westward to 51.2°N, 152.7°W so that the instruments were spaced more evenly. During the May 2000 deployment, two of the five instruments experienced hard drive failures: the hydrophone deployed at 50°N, 135°W failed only 50 d into the deployment (25 June 2000) and the hydrophone at 51.2°N, 152.7°W failed 200 d into deployment (15 December 2000).

The instruments were, on average, 736.6 ± 338.4 km apart in 1999 and 820.6 ± 415.1 km apart in 2000 making it unlikely that the same call was heard simultaneously on more than one instrument.

A subsample of 15% of the hours of available data was randomly chosen for data analysis. The same hours were examined for each hydrophone (12,749 of ~63,000 total hours from eleven deployments: six in 1999 and five in 2000). These hours were examined as spectrograms and presence (+), absence (–), and call type detected were noted. The proportion of hours with calls over the number of hours of data was plotted to explore seasonal trends. To examine the contemporaneous temporal and spatial overlap of the two call types, the proportion of hours with both call types over the hours with northeastern and/or northwestern call types was determined.

RESULTS

Both northeastern and northwestern blue whale call types were recorded in the Gulf of Alaska (Fig. 2). There was a strong seasonal signal in histograms of both call types (Fig. 3). Both were recorded from the start of data collection in October 1999

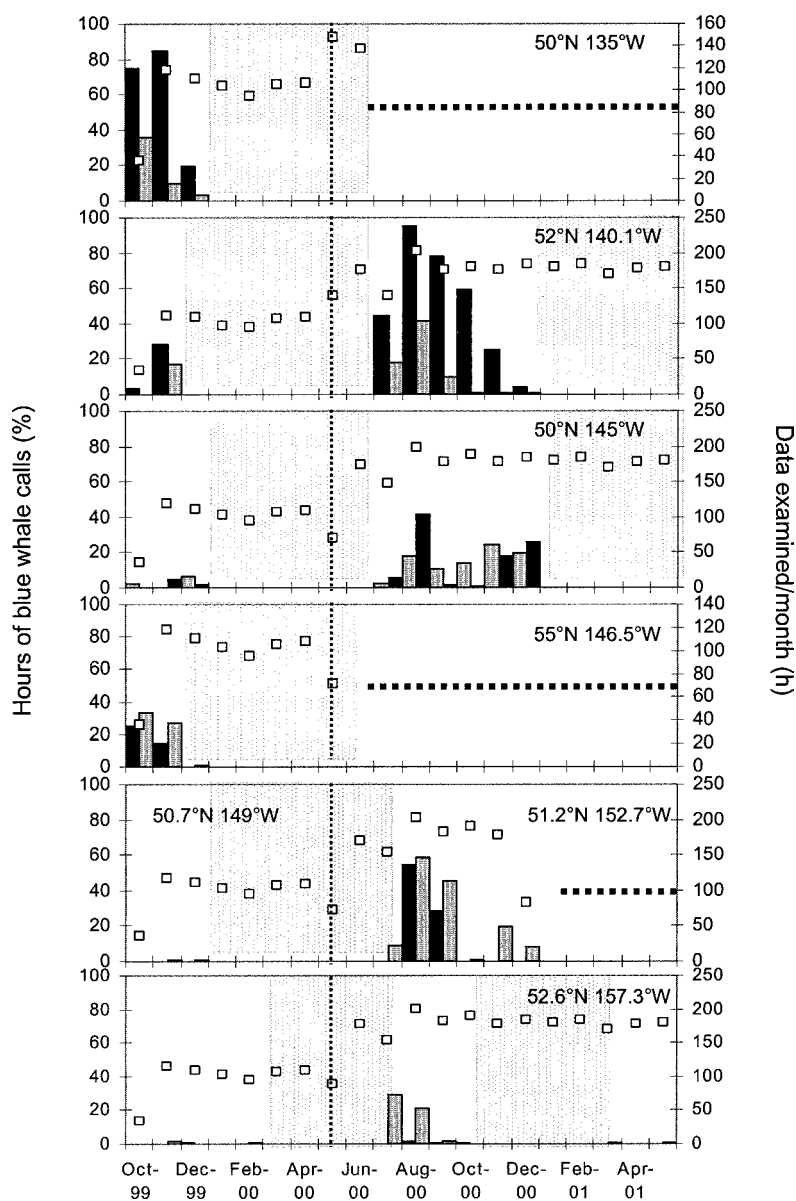


Figure 3. Occurrence of blue whale calls on the hydrophones in the Gulf of Alaska from October 1999 to May 2001. Histograms are shown from easternmost (top histogram) to westernmost (bottom histogram). Hydrophone locations are shown in the upper left and right corners of each graph. Percentage of hours per month during which blue whale calls were recorded is shown on the left axes. Northeastern call occurrence is shown as black bars and northwestern call occurrence is shown as gray bars. Time periods when no calls were detected are shaded gray. The number of hours of data examined by month is shown on the right axes. The dashed horizontal line indicates times when no data were available. The dashed vertical line separates the two deployments.

through December 1999. No northeastern Pacific call types were recorded from the third week of December 1999 until mid-July 2000. After this date they were detected on all four hydrophones through mid-December 2000, but not after that for the remainder of the deployment (beginning of June 2001). No northwestern Pacific call types were recorded after the third week in December 1999, either, with the exception of several calls recorded during 1 h in February 2000. Northwestern Pacific calls were detected again in early July 2000 through mid-December 2000.

Overall, northeastern Pacific call types were recorded more often than northwestern Pacific call types in both 1999 and 2000 (Fig. 3). During the October 1999–May 2000 deployments, northeastern Pacific call types were recorded on five of the six hydrophones (all but 50.7°N, 149°W and at very low levels at 52.6°N, 157.3°W), and northwestern call types were recorded on all six hydrophones, but at lower levels than the northeastern calls. Northeastern Pacific call types were recorded on four of the five hydrophones during the May 2000–June 2001 deployments (Fig. 3). In 1999, northeastern call types were recorded most often on the hydrophone at 50°N, 135°W while the northwestern Pacific call types were recorded most often on the hydrophone at 55°N, 146.5°W. The two call types were seldom recorded on either the 52.6°N, 157.3°W or the 50.7°N, 149°W hydrophones (Fig. 3).

As in 1999–2000, northeastern Pacific calls were recorded infrequently on the hydrophone at 52.6°N, 157.3°W. The northeastern Pacific call type was recorded most often on the hydrophone at 52°N, 140.1°W from August to October 2000 (Fig. 3). Northwestern Pacific calls were also recorded on four of five hydrophones deployed from May 2000 to June 2001. Northwestern Pacific calls were recorded most often on all hydrophones (except 52.6°N, 157.3°W where they were recorded most often in July) in August 2000 (Fig. 3).

Both northeastern and northwestern call types showed temporal and spatial overlap in the Gulf of Alaska. These call types were recorded simultaneously on the hydrophones at 50°N, 135°W, 52°N, 140.1°W, and 55°N, 146.5°W in October–November 1999. Both types of calls were recorded on the same hydrophone during the same hour at 51.2°N, 152.7°W, 52°N, 140.1°W, and 50°N, 144.8°W in August 2000 and on at least one of these hydrophones July–December 2000 (Fig. 4).

Although the two call types clearly overlap in the Gulf of Alaska, an east-west trend in the frequency of call by types is also apparent. The occurrence of northeastern Pacific call types decreases slightly from the east to the west and the occurrence of northwestern Pacific call types increases from east to west (Fig. 3).

DISCUSSION

The recording of two blue whale call types in the Gulf of Alaska confirms the presence of blue whales in the Gulf of Alaska and suggests that perhaps two populations of blue whales use this area. These data extend the geographic range of the northeastern call type from the eastern tropical Pacific up into the Gulf of Alaska. Blue whales are considered to be more pelagic than coastal (Tomilin 1957, Pike and MacAskie 1969, Rice 1974) and because of this Tomilin (1957) predicted that blue whales from the eastern and western parts of the North Pacific were not isolated from each other. The data presented here, then, do not support a separate eastern Gulf of Alaska population (NMFS 1998) of blue whales, but indicate that this is an area of overlap for the animals that make northeastern and northwestern call types, as was hypothesized by Stafford *et al.* (2001).

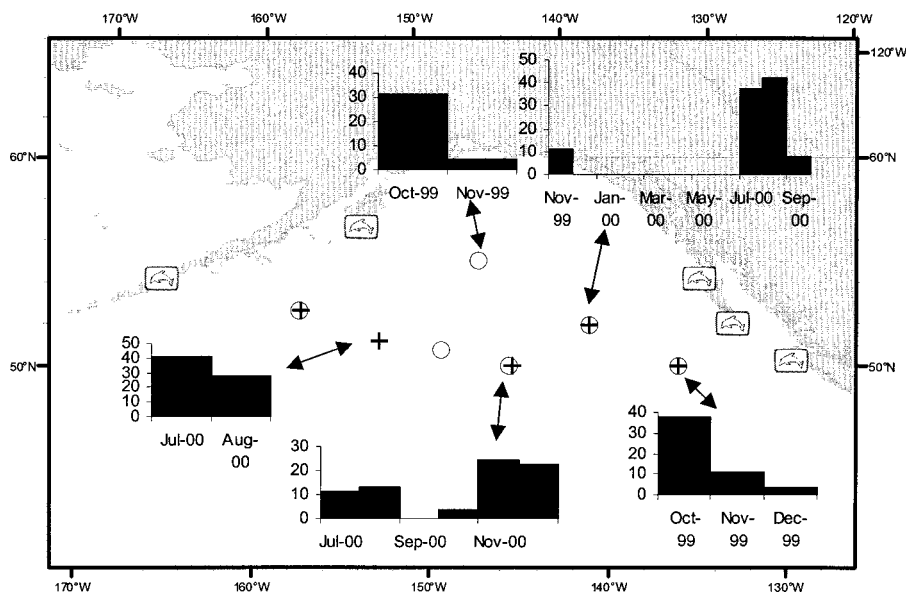


Figure 4. Map showing the percentage of hours by month during which northeastern and northwestern Pacific call types were recorded on the same hydrophone during the same hour. Only those months with this temporal and spatial overlap are shown. Hydrophone deployment dates are the same as in Figure 1. There was no overlap at either 50.7°N 149°W or 52.6°N 157.3°W. Arrows associate the histograms with the locations from which the data were obtained. Locations of former whaling stations are shown as dolphins.

Because so little is known about the population dynamics of blue whales, it is difficult to discern whether the differences between eastern and western North Pacific blue whale calls are a dialect or are true geographic variation. In general, “dialects” are detectable differences in sounds produced by neighboring populations of conspecifics that have the potential to interbreed (Nottebohm 1972). Geographic variation, on the other hand, may represent differences that arise from genetic isolation perhaps due to physical barriers, and “biologically significant” geographic variation is that which is exhibited by populations between which there exists no significant physical barrier (Conner 1982). In the North Pacific there is no obvious physical barrier between eastern and western populations of blue whales, although they are recorded at widely separated regions of the North Pacific during most of the year (Stafford *et al.* 2001).

Different acoustic call types may, or may not, be associated with long-term separation of populations, and so caution needs to be used in the interpretation of acoustic differences. Humpback whales are the only baleenopterid species for which acoustics have been integrated into an understanding of the population structure. In the North Pacific, humpback whales are found in the winter on discrete breeding grounds off Mexico, Hawaii, and Japan but summer throughout the North Pacific with animals from different wintering areas intermixing on feeding grounds to which they show some fidelity (Calambokidis *et al.* 1996, 2000). Male humpback whales use song as a display on the wintering grounds, although whether this display is to attract females, deter other males or both is unclear (Tyack 1981). These songs show broad scale geographic variation (Winn *et al.* 1981; Helweg *et al.*

1990, 1998), but are also highly plastic: these songs can change within and between years (Winn and Winn 1978, 1981; Payne and Payne 1985; Cato 1991). The rapid adoption of the west Australian song type by the east Australian population of humpback whales despite only small interchange between the two populations suggests that, for humpback whales, song may only be used in the short term as an indicator of geographic variation (Noad *et al.* 2000).

Unlike humpback whales, very little is known of the function(s) or history of sound production in blue whales, therefore determining the significance of the east-west difference in North Pacific blue whale calls requires more information than just the acoustic differences. Because of this, it will be important to supplement sightings of blue whales in this area with identification photographs and genetic and acoustic sampling in order to better understand potential population differences between animals that produce the two call types documented here. Additionally, more acoustic data are required to better establish intra-Gulf geographical and seasonal differences among locations and years.

Gilpatrick *et al.*³ plotted all the catches and sightings of blue whales in the North Pacific from 1924 to 1965. Most of the catches were relatively near shore, as were the catches from land stations presented by Brueggeman *et al.* (1985) and Reeves *et al.* (1985). The locations of the Gulf of Alaska hydrophones are well offshore of many of these catches. They are also well beyond the range of line transect surveys undertaken in the Gulf of Alaska to monitor cetaceans (Rice and Wolman 1982). However, the sighting data show blue whales throughout much of the central Gulf of Alaska and particularly in the eastern Gulf of Alaska³ where most of the blue whale calls reported in this study were recorded.

Northwestern Pacific blue whale calls recorded at similar latitudes but farther west in the North Pacific have a slightly longer "acoustic season" than those in the Gulf of Alaska. This call type has been recorded on U.S. Navy arrays from June through February, although the arrays closest to the western Gulf of Alaska record these sounds primarily from July through December as reported here (Watkins *et al.* 2000, Stafford *et al.* 2001).

The most recent dedicated visual survey of cetaceans in the Gulf of Alaska occurred from 17 June to 28 August 1980 (Rice and Wolman 1982) and surveys of former Aleutian whaling grounds occurred from 26 July to 26 August 1985 and August 1994¹ (Stewart *et al.* 1987). This dearth of contemporary survey data in the Gulf of Alaska combined with recent acoustic detections suggests that it may be time to revisit the Gulf of Alaska in order to update visual sighting data in this area.

Also relevant to this study is the obvious value of acoustic methods to monitor large areas over long time periods. These instruments can be placed in remote parts of the ocean that are seldom visited by survey vessels and can provide information on broad-scale patterns of seasonal and geographic occurrence. This has been shown in the Atlantic Ocean where blue, fin (*B. physalus*), minke (*B. acutorostrata*), and humpback whales have been monitored and tracked over large regions for long periods of time (Clark 1995, Charif *et al.* 2001). In the eastern tropical Pacific long term acoustic data were used to show that populations of blue whales from both the northern and southern hemisphere are found there, but at opposite times of the year

³ Gilpatrick, J., W. Perryman, L. Lynn and M. A. DeAngelis. 1996. Geographic populations of blue whales (*Balaenoptera musculus*) in the North Pacific Ocean investigated from whaling records and aerial photogrammetry. Paper SC/47/NP4 presented to the International Whaling Commission Scientific Committee, May 1995 (unpublished). Available from SW Fisheries Science Center, La Jolla, California.

(Stafford *et al.* 1999b). Finally, in the North Pacific Ocean, the sounds of blue, fin, and humpback whales have been detected from regions and during seasons that would never have been the target of visual surveys for these animals (Thompson and Friedl 1982, Moore *et al.* 1998, Stafford *et al.* 1999b, Curtis *et al.* 1999, Watkins *et al.* 2000, Stafford *et al.* 2001).

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